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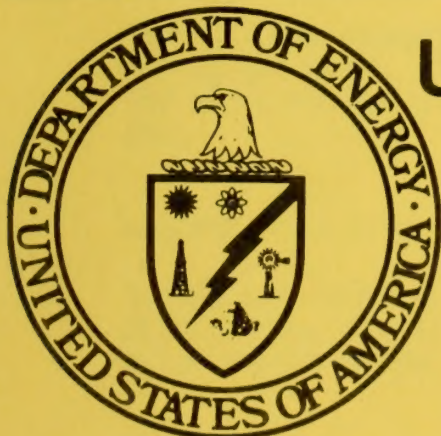
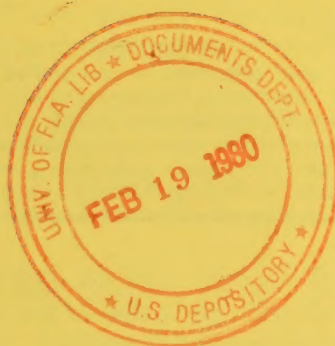
Alph 1215966

SOLAR/1017-79/03

# Monthly Performance Report

FACILITIES DEVELOPMENT

MARCH 1979



## U.S. Department of Energy

National Solar Heating and  
Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT  
FACILITIES DEVELOPMENT GAS COMPANY

MARCH 1979

I. SYSTEM DESCRIPTION

The Facilities Development Gas Company site is a three-story, multifamily condominium consisting of 31 units in San Diego, California. Solar energy is used for preheating domestic hot water (DHW) for the complex. The solar energy system has an array of flat-plate collectors with a gross area of 520 square feet. The array faces south at an angle of 42 degrees to the horizontal. Potable water is the transfer medium that delivers solar energy from the collector array to storage. Solar energy is stored underground in an insulated 1000-gallon glass-lined tank. Preheated water from the storage tank is supplied, on demand, to 31 conventional 52-gallon DHW tanks. When solar energy is insufficient to satisfy the hot water load, two electrical heating elements, energized separately within the individual DHW tanks, provide auxiliary energy for water heating. The system, shown schematically in Figure 1, has two modes of solar operation.

Mode 1 - Collector-to-Storage: This mode activates when the water temperature in the collectors is 9°F higher than the temperature of the storage tank. Water is pumped through the collectors and circulates back to storage until the temperature difference is 3°F or less.

Mode 2 - Storage-to-DHW Tank: This mode activates when there is a demand for hot water replenishment by the individual DHW tank. Water from storage circulates by thermosiphoning action through a supply service loop to the individual DHW tanks and returns through a service line to storage. The water in each DHW tank is maintained at an average temperature which is thermostatically controlled. When required, additional energy is supplied by an electrical auxiliary element.

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was occupied in March and the solar energy system operated continuously during the month. Solar energy satisfied 20 percent of the DHW requirements. The solar energy system provided electrical energy savings of 10.9 million Btu.

WEATHER CONDITIONS

During the month, total incident solar energy on the collector array was 25.7 million Btu for a daily average of 1595 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area

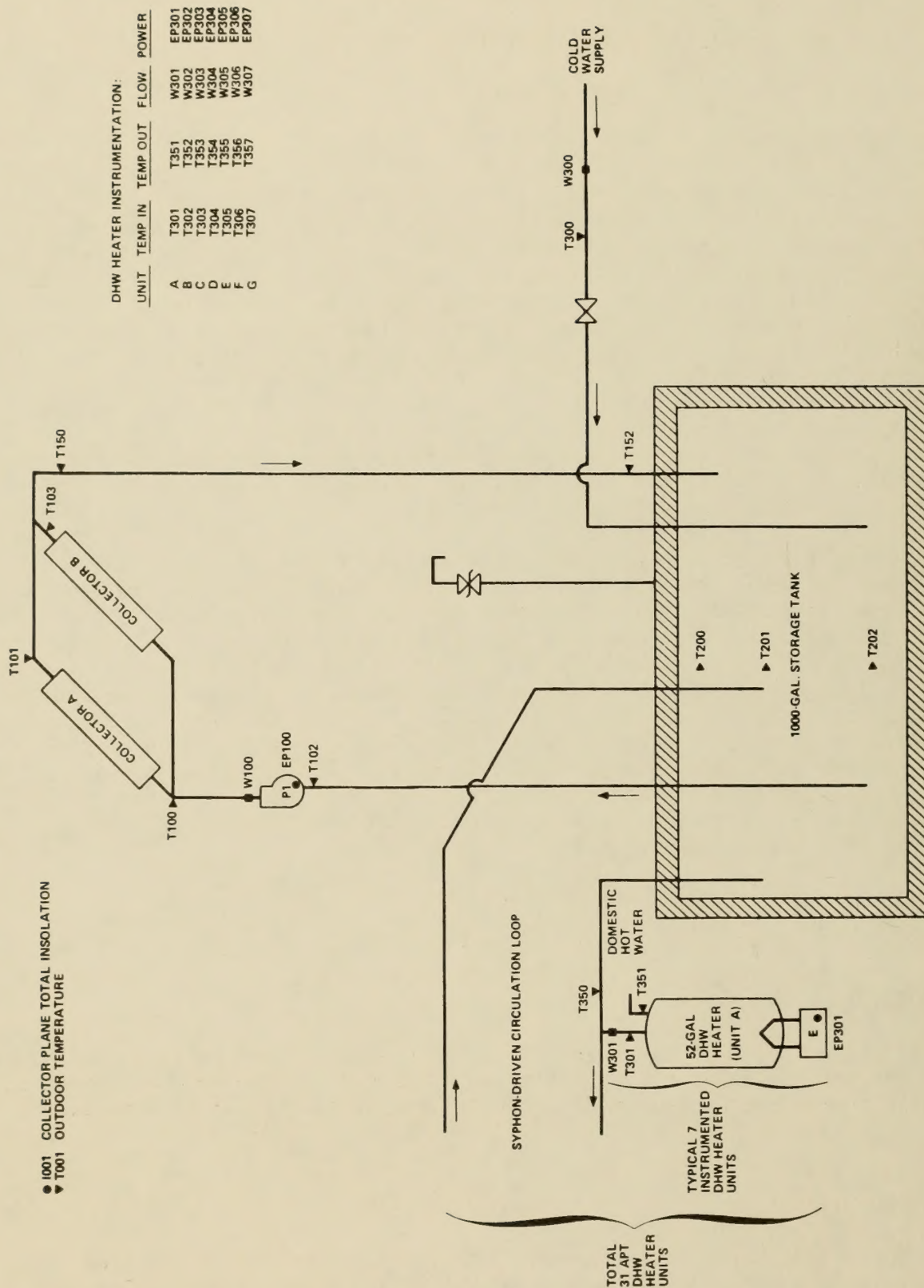


Figure 1. FACILITIES DEVELOPMENT SOLAR ENERGY SYSTEM SCHEMATIC



during March of 1892 Btu per square foot for a south-facing plane with a tilt of 42 degrees to the horizontal. The average ambient temperature during March was 57°F as compared with the long-term average for March of 58°F. The number of heating degree-days for the month (based on a 65°F reference) was 258, as compared with the long-term average of 219.

#### THERMAL PERFORMANCE

System - During March the solar energy system performed approximately the same as expected. The expected performance was determined from a modified f-chart analysis using measured weather and subsystem loads as inputs. Solar energy collected was 12.2 million Btu versus an estimated 11.5 million Btu. Solar energy used by the system was estimated by assuming that all energy collected would be applied to the load. Actual solar energy used was 11.1 million Btu. System total solar fraction was 20 percent versus an estimated 20 percent.

Collector - The total incident solar radiation on the collector array for the month of March was 25.7 million Btu. During the period the collector loop was operating, the total insolation amounted to 23.2 million Btu. The total collected solar energy for the month of March was 12.2 million Btu, resulting in a collector array efficiency of 47 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 10.8 million Btu. Energy loss during transfer from the collector array to storage was 1.3 million Btu. This loss represented 11 percent of the energy collected. Operating energy required by the collector loop was 0.23 million Btu.

Storage - Solar energy delivered to storage was 10.8 million Btu. There were 11.1 million Btu delivered from storage to the DHW subsystem. There was no apparent energy loss from storage. The storage efficiency was 100 percent: This is calculated as the ratio of the sum of the energy removed from storage and the change in stored energy, to the energy delivered to storage. The average storage temperature for the month was 89°F.

DHW Load - The DHW subsystem consumed 11.1 million Btu of solar energy and 45.8 million Btu of auxiliary electrical energy. The solar fraction of the hot water load was 20 percent. The hot water load was not determined. The DHW subsystem resulted in an electrical energy savings of 11.1 million Btu. A daily average of 1189 gallons of DHW was consumed.

#### OBSERVATIONS

The collected solar energy, the collector loop operating energy, energy delivered to storage, solar energy used, and hot water consumed, were derived from overall solar energy system parameters. The auxiliary electrical energy used (representing the entire building) was extrapolated from the averages of seven instrumented apartment units.

The hot water load and the average value of the hot water temperature supplied to the building has not been determined because of inadequate instrumentation.

## ENERGY SAVINGS

The solar energy system provided a total electrical energy savings of 10.9 million Btu.

## III. ACTION STATUS

No action is required at this time.



# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT SITE SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY  
REPORT PERIOD: MARCH, 1979

SOLAR/1017-79/03

### SITE/SYSTEM DESCRIPTION:

THE FACILITIES DEVELOPMENT SOLAR SYSTEM PROVIDES SERVICE HOT WATER TO 31 UNITS OF A CONDOMINIUM. ALL UNITS HAVE 52 GALLON ELECTRIC WATER HEATERS. SEVEN OF THESE ARE INSTRUMENTED. THE ARRAY OF FLAT-PLATE COLLECTORS PROVIDES 520 SQUARE FEET OF GROSS AREA. STORAGE IS PROVIDED BY A SINGLE 1000 GALLON GLASS LINED TANK, INSULATED AND BURIED.

### GENERAL SITE DATA:

INCIDENT SOLAR ENERGY 25.708 MILLION BTU  
COLLECTED SOLAR ENERGY 49438 BTU/SQ.FT.  
AVERAGE AMBIENT TEMPERATURE 12.154 MILLION BTU  
AVERAGE BUILDING TEMPERATURE 23372 BTU/SQ.FT.  
ECSS SOLAR CONVERSION EFFICIENCY 57 DEGREES F  
ECSS OPERATING ENERGY N.A. DEGREES F  
TOTAL SYSTEM OPERATING ENERGY 0.43  
TOTAL ENERGY CONSUMED 0.234 MILLION BTU  
58.224 MILLION BTU

### SUBSYSTEM SUMMARY:

	FCT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	N.A.	N.A.	N.A. MILLION BTU
SOLAR FRACTION USED	N.A.	N.A.	N.A.	N.A. PERCENT
SOLAR ENERGY USED	11.127	N.A.	N.A.	11.127 MILLION BTU
OPERATING ENERGY	N.A.	N.A.	N.A.	0.234 MILLION BTU
AUX. THERMAL ENERGY	45.836	N.A.	N.A.	45.836 MILLION BTU
AUX. ELECTRIC FUEL	45.836	N.A.	N.A.	45.836 MILLION BTU
AUX. FCSSIL FUEL	N.A.	N.A.	N.A.	N.A. MILLION BTU
ELECTRICAL SAVINGS	11.127	N.A.	N.A.	10.892 MILLION BTU
FCSSIL SAVINGS	N.A.	N.A.	N.A.	N.A. MILLION BTU

### SYSTEM PERFORMANCE FACTOR:

\* DENOTES UNAVAILABLE DATA  
# DENOTES NULL DATA  
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT  
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978.  
SOLAR/0004-78/18

# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT SITE SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY  
REPORT PERIOD: MARCH, 1979

SOLAR/1017-79/03

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### GENERAL SITE DATA:

INCIDENT SOLAR ENERGY

COLLECTED SOLAR ENERGY

AVERAGE AMBIENT TEMPERATURE  
AVERAGE BUILDING TEMPERATURE  
GROSS SOLAR CONVERSION EFFICIENCY  
GROSS OPERATING ENERGY  
TOTAL SYSTEM OPERATING ENERGY  
TOTAL ENERGY CONSUMED

27.121 GIGA JOULES  
561417 KJ/SQ.M.  
12.822 GIGA JOULES  
265417 KJ/SQ.M.  
14 DEGREES C  
N.A. DEGREES C  
0.43  
0.247 GIGA JOULES  
0.247 GIGA JOULES  
61.426 GIGA JOULES

### SUBSYSTEM SUMMARY:

LCAD  
SOLAR FRACTION USED  
SOLAR ENERGY USED  
OPERATING ENERGY  
AUX. THERMAL ENG  
AUX. ELECTRIC FUEL  
AUX. FCSSIL FUEL  
ELECTRICAL SAVINGS  
FCSSIL SAVINGS

HOT WATER  
N.A.  
N.A.  
11.739  
N.A.  
48.357  
48.357  
N.A.  
11.739  
N.A.

HEATING  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.

COOLING  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.

SYSTEM TOTAL  
N.A. GIGA JOULES  
N.A. PERCENT  
11.739 GIGA JOULES  
0.247 GIGA JOULES  
48.357 GIGA JOULES  
48.357 GIGA JOULES  
N.A. GIGA JOULES  
11.491 GIGA JOULES  
N.A. GIGA JOULES

### SYSTEM PERFORMANCE FACTOR:

\* DENOTES UNAVAILABLE DATA  
@ DENOTES NULL DATA  
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT  
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978,  
SOLAR/0004-78/18



# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: FACILITIES DEVELOPMENT GAS COMPANY  
REPORT PERIOD: MARCH, 1975

SOLAR/1017-79/03

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	ALX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.058	53	0.267	NCT	0.002	NCT	3.731
2	1.041	50	0.226		0.010		0.217
3	1.097	51	0.384		0.010		0.350
4	1.073	55	0.492		0.010		0.458
5	1.076	59	0.371		0.010		0.345
6	1.129	63	0.507		0.010		0.449
7	1.120	65	0.644		0.010		0.575
8	1.049	59	0.411		0.009		0.392
9	0.587	58	0.346		0.007		0.589
10	0.817	58	0.316		0.008		0.387
11	1.044	58	0.484		0.009		0.463
12	0.957	58	0.454		0.009		0.474
13	0.495	55	0.332		0.008		0.671
14	1.070	59	0.328		0.010		0.307
15	0.567	57	0.246		0.007		0.611
16	0.934	56	0.321		0.007		0.343
17	0.746	54	0.255		0.006		0.395
18	0.542	53	0.244		0.004		0.450
19	0.615	54	0.243		0.005		0.394
20	0.537	53	0.250		0.004		0.465
21	0.472	56	0.188		0.006		0.398
22	0.812	56	0.271		0.008		0.334
23	1.082	54	0.386		0.009		0.357
24	1.091	56	0.474		0.009		0.434
25	1.010	57	0.383		0.008		0.379
26	0.815	60	0.438		0.007		0.537
27	0.081	58	0.203		0.000		2.507
28	0.612	58	0.174		0.006		0.284
29	0.977	56	0.333		0.008		0.341
30	1.100	56	0.450		0.009		0.409
31	1.062	56	0.466		0.009		0.440
SUM	25.708	-	11.127	N.A.	0.234	N.A.	-
AVG	0.825	57	0.355	N.A.	0.008	N.A.	0.433
NBS ID	0001	N113			G102		N111

\* DENOTES UNAVAILABLE DATA.  
# DENOTES NULL DATA.  
N.A. DENOTES NOT APPLICABLE DATA.



# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT COLLECTOR ARRAY PERFORMANCE

SITE: FACILITIES DEVELOPMENT GAS COMPANY SCLAR/1017-79/03  
REPORT PERIOD: MARCH, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.058	0.046	0.021	53	0.211
2	1.041	0.957	0.487	59	0.468
3	1.057	1.032	0.470	61	0.428
4	1.073	1.031	0.522	64	0.487
5	1.076	1.031	0.522	69	0.485
6	1.129	1.094	0.566	75	0.501
7	1.120	1.084	0.580	81	0.518
8	1.049	1.021	0.533	64	0.508
9	0.587	0.540	0.297	62	0.506
10	0.817	0.762	0.399	64	0.488
11	1.044	0.974	0.503	65	0.482
12	0.957	0.916	0.485	66	0.507
13	0.495	0.441	0.247	62	0.498
14	1.070	1.016	0.502	64	0.469
15	0.567	0.505	0.275	61	0.491
16	0.934	0.821	0.434	61	0.464
17	0.746	0.654	0.342	58	0.458
18	0.542	0.339	0.216	59	0.399
19	0.615	0.441	0.280	58	0.454
20	0.537	0.353	0.226	54	0.421
21	0.472	0.384	0.224	61	0.474
22	0.812	0.741	0.409	63	0.504
23	1.082	0.987	0.506	62	0.468
24	1.091	0.993	0.471	64	0.432
25	1.010	0.929	0.480	65	0.475
26	0.815	0.720	0.408	64	0.500
27	0.081	0.000	0.000	58	0.002
28	0.612	0.522	0.292	60	0.477
29	0.977	0.852	0.478	61	0.489
30	1.100	0.988	0.502	62	0.456
31	1.062	0.945	0.475	64	0.447
SUM	25.708	23.158	12.154	-	-
AVG	0.829	0.747	0.392	63	0.473
NESID	0001		G100		N100

\* DENOTES UNAVAILABLE DATA.  
 ‡ DENOTES NULL DATA.  
 N.A. DENOTES NOT APPLICABLE DATA.



# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT STORAGE PERFORMANCE

SITE: FACILITIES DEVELOPMENT GAS COMPANY  
 REPORT PERIOD: MARCH, 1979  
 SOLAR/1017-79/03

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.029	0.367	-0.445	79	-2.806
2	0.430	0.226	0.205	84	0.958
3	0.370	0.384	0.013	96	1.072
4	0.488	0.452	-0.035	96	0.935
5	0.455	0.371	0.082	99	1.001
6	0.507	0.507	0.000	104	1.016
7	0.468	0.644	-0.025	103	1.323
8	0.477	0.411	0.027	98	0.805
9	0.262	0.346	-0.087	85	0.988
10	0.352	0.316	0.051	90	1.042
11	0.475	0.484	-0.012	96	1.042
12	0.427	0.454	-0.011	93	1.038
13	0.230	0.332	-0.091	80	1.048
14	0.431	0.328	0.149	93	1.107
15	0.257	0.346	-0.091	88	0.995
16	0.382	0.321	0.080	92	1.048
17	0.307	0.255	0.068	92	0.738
18	0.194	0.244	-0.063	83	0.535
19	0.244	0.243	0.002	80	1.002
20	0.212	0.250	-0.047	75	0.560
21	0.203	0.188	0.013	75	0.993
22	0.355	0.271	0.064	83	0.543
23	0.455	0.386	0.119	93	1.100
24	0.407	0.474	-0.046	102	1.052
25	0.425	0.383	0.021	98	0.951
26	0.375	0.438	-0.074	93	0.570
27	0.004	0.203	-0.196	69	2.011
28	0.273	0.174	0.120	72	1.077
29	0.426	0.333	0.103	86	1.002
30	0.446	0.450	0.052	95	1.125
31	0.415	0.468	-0.035	98	1.033
SUM	10.818	11.127	-0.248	-	-
AVG	0.349	0.355	-0.008	89	1.006
NES ID	Q200	Q201	Q202	-	N108

\* DENOTES UNAVAILABLE DATA.  
 @ DENOTES NULL DATA.  
 N.A. DENOTES NOT APPLICABLE DATA.

# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT HCT WATER SUBSYSTEM

SOLAR/1017-79/03

SITE: FACILITIES DEVELOPMENT GAS COMPANY  
REPORT PERIOD: MARCH, 1979

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR. OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	CFER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FCSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	NOT	NOT	0.367	1.098	1.098	1.098	NOT	0.367	NOT	59	NOT	1331
2	NOT	NOT	0.226	1.560	1.560	1.560	NOT	0.226	NOT	60	NOT	1128
3	NOT	NOT	0.384	1.208	1.208	1.208	NOT	0.384	NOT	60	NOT	965
4	NOT	NOT	0.452	1.323	1.323	1.323	NOT	0.452	NOT	59	NOT	1270
5	APPL	APPL	0.371	1.367	1.367	1.367	APPL	0.371	APPL	60	APPL	952
6	APPL	APPL	0.507	1.269	1.269	1.269	APPL	0.507	APPL	60	APPL	1197
7	APPL	APPL	0.644	1.271	1.271	1.271	APPL	0.644	APPL	60	APPL	1521
8	APPL	APPL	0.411	1.534	1.534	1.534	APPL	0.411	APPL	59	APPL	1142
9	APPL	APPL	0.346	1.311	1.311	1.311	APPL	0.346	APPL	59	APPL	1244
10	APPL	APPL	0.316	1.305	1.305	1.305	APPL	0.316	APPL	59	APPL	1015
11	APPL	APPL	0.454	1.658	1.658	1.658	APPL	0.454	APPL	59	APPL	1248
12	APPL	APPL	0.332	1.599	1.599	1.599	APPL	0.332	APPL	59	APPL	1505
13	APPL	APPL	0.328	1.470	1.470	1.470	APPL	0.328	APPL	60	APPL	1072
14	APPL	APPL	0.346	1.023	1.023	1.023	APPL	0.346	APPL	61	APPL	1122
15	APPL	APPL	0.321	1.334	1.334	1.334	APPL	0.321	APPL	61	APPL	1088
16	APPL	APPL	0.255	1.141	1.141	1.141	APPL	0.255	APPL	61	APPL	1102
17	APPL	APPL	0.244	1.476	1.476	1.476	APPL	0.244	APPL	60	APPL	1038
18	APPL	APPL	0.243	1.267	1.267	1.267	APPL	0.243	APPL	60	APPL	1163
19	APPL	APPL	0.250	1.944	1.944	1.944	APPL	0.250	APPL	59	APPL	1390
20	APPL	APPL	0.168	2.023	2.023	2.023	APPL	0.168	APPL	59	APPL	1177
21	APPL	APPL	0.271	1.935	1.935	1.935	APPL	0.271	APPL	59	APPL	1113
22	APPL	APPL	0.386	1.451	1.451	1.451	APPL	0.386	APPL	59	APPL	1354
23	APPL	APPL	0.474	1.871	1.871	1.871	APPL	0.474	APPL	60	APPL	1126
24	APPL	APPL	0.383	1.314	1.314	1.314	APPL	0.383	APPL	59	APPL	941
25	APPL	APPL	0.438	1.276	1.276	1.276	APPL	0.438	APPL	60	APPL	1209
26	APPL	APPL	0.203	1.453	1.453	1.453	APPL	0.203	APPL	60	APPL	1257
27	APPL	APPL	0.174	1.854	1.854	1.854	APPL	0.174	APPL	60	APPL	1186
28	APPL	APPL	0.333	2.012	2.012	2.012	APPL	0.333	APPL	60	APPL	1170
29	APPL	APPL	0.450	1.832	1.832	1.832	APPL	0.450	APPL	60	APPL	1277
30	APPL	APPL	0.468	1.474	1.474	1.474	APPL	0.468	APPL	61	APPL	1202
31	APPL	APPL	0.468	1.184	1.184	1.184	APPL	0.468	APPL	61	APPL	1202
SUM	N.A.	-	11.127	45.836	45.836	45.836	N.A.	11.127	N.A.	-	-	36859
AVG	N.A.	N.A.	0.359	1.479	1.479	1.479	N.A.	0.359	N.A.	60	N.A.	1189
NBS	Q302	N300	G300	G301	G301	G305	Q306	Q311	G313	N305	N307	N308

\* DENGIES UNAVAILABLE DATA.  
 & DENGIES NULL DATA.  
 N.A. DENOTES NOT APPLICABLE DATA.



# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT ENVIRONMENTAL SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY  
REPORT PERIOD: MARCH, 1979

SOLAR/1017-79/03

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	189	N	53	53	N	NOT	N
2	2001	C	50	59	T	NOT	C
3	2109	T	51	61			T
4	2063		55	64			
5	2065	A	59	65			A
6	2172	P	63	75			P
7	2154	P	65	81			P
8	2017	P	59	64			P
9	1128	P	58	62			P
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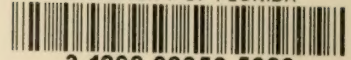
\* DENOTES UNAVAILABLE DATA.  
@ DENOTES NULL DATA.  
N.A. DENOTES NOT APPLICABLE DATA.







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